CLAIMS

What is claimed is:

1. An implantable microstimulator, comprising:

an hermetically-sealed housing having a length no greater than about 27 mm and cross-sectional dimensions no greater than about 3.3 mm;

an electronic subassembly housed within said hermetically-sealed housing;

self-contained power source means contained within said hermetically-sealed housing and operatively connected to said electronic subassembly for providing operating power to said electronic subassembly;

a first electrode external to said hermetically-sealed housing and electrically coupled to said electronic subassembly;

a second electrode external to said hermetically-sealed housing and electrically coupled to said electronic subassembly;

an antenna coil within said hermetically-sealed housing; and

telemetry means, coupled to said antenna coil, for allowing data-containing signals to be received from an external device, said telemetry means comprising

a first telemetry receiver for receiving data in accordance with a first telemetry scheme, and

a second telemetry receiver for receiving data in accordance with a second telemetry scheme.

2. The implantable microstimulator of Claim 1 wherein the electronic subassembly includes a ferrite core around which the antenna coil is wrapped.

3. The implantable microstimulator of Claim 2 wherein the ferrite core includes a first half and a second half.

4. The implantable microstimulator of Claim 2 wherein the first telemetry scheme comprises a binary frequency shift key (BFSK) scheme wherein a binary "1" is represented by a transmitted signal of a first frequency F1, and wherein a binary "0" is represented by a transmitted signal of a second frequency F2.

5. The implantable microstimulator of Claim 4 wherein the first telemetry receiver includes a capacitor for tuning the antenna coil wrapped around the ferrite core to a frequency that is close to both the first frequency F1 and the second frequency F2, whereby both the first frequency F1 and the second frequency F2 may be received through the antenna coil with minimal degradation.

6. The implantable microstimulator of Claim 5 wherein the first telemetry receiver includes a mixer circuit and a local oscillator circuit, and wherein the local oscillator circuit generates a local oscillator signal having a frequency F3, and wherein the received BFSK signal is mixed with the local oscillator signal at the mixer circuit to produce a difference signal, and wherein the local oscillator signal F3 is approximately mid way between the frequency F1 and F2.

7. The implantable microstimulator of Claim 6 wherein the first frequency F1 is about 131 KHz, and the second frequency F2 is about 123 KHz, and the frequency F3 of the local oscillator signal is about 127 KHz.

8. The implantable microstimulator of Claim 4 wherein the second telemetry scheme comprises an ON-OFF-KEY (OOK) Pulse Width Modulation (PWM) scheme,

wherein a binary "0" is represented by a first pulse width PW1 and a binary "1" is represented by a second pulse width PW2, and wherein a transition between one data bit and an adjacent data bit is marked by a change in a transmitted data signal from an ON to an OFF state, or from an OFF to an ON state, wherein the ON state is characterized by the presence of a data signal having a frequency F1', and wherein the OFF state is characterized by the absence of the data signal.

9. The implantable microstimulator of Claim 8 wherein the telemetry means further includes means for transmitting a signal to the external device in accordance with the BFSK telemetry scheme.

10. A neurostimulator system comprising:

a remote control unit;

a base station; and

an implantable microstimulator, including means for generating stimulation pulses in accordance with programmed parameters;

wherein the remote control unit includes telemetry means for communicating with the implantable microstimulator in accordance with a radio frequency (RF) telemetry link; and

wherein the base station includes a telemetry means for communicating with the implantable microstimulator in accordance with at least one of a RF telemetry link or an electromagnetic inductive telemetry link; and

wherein the remote control unit and base station include means for communicating with each other through an Infrared (IR) communication link.

11. The neurostimulator system of Claim 10 wherein data is communicated through the RF telemetry link in accordance with a binary frequency shift key (BSFK) modulation scheme, wherein a binary "1" is represented by a first frequency F1 in the transmitted data signal, and wherein a binary "0" is represented by a second frequency F2 in the transmitted data signal.

12. The neurostimulator system of Claim 11 wherein the base station includes a chair pad coupled thereto, and wherein at least one coil is embedded within said chair pad, and further wherein data is communicated through the RF telemetry link and the coil in the chair pad in accordance with a BSFK modulation scheme, and wherein data is communicated through the electromagnetic inductive telemetry link and the coil in the chair pad in accordance with an ON-OFF-KEY Pulse Width Modulation (OOK-PWM) modulation scheme.

13. The neurostimulator system of Claim 12 further including a clinician's programer having an IR communication link for communicating with the base station and the remote control.

14. The neurostimulator system of Claim 12 wherein implantable microstimulator comprises:

an hermetically-sealed housing having a length no greater than about 27 mm and cross-sectional dimensions no greater than about 3.3 mm;

an electronic subassembly housed within said hermetically-sealed housing;

self-contained power source means within said hermetically-sealed housing and operatively connected to said electronic subassembly for providing operating power to said electronic subassembly;

first and second electrodes external to said hermetically-sealed housing and electrically coupled to said electronic subassembly;

an antenna coil within said hermetically-sealed housing; and

telemetry means, coupled to said antenna coil, for allowing data-containing signals to be received from the remote control and the base station through the RF telemetry link and the electromagnetic inductive telemetry link, whereby two separate telemetry links are provided for communicating with the implantable microstimulator.

15. The neurostimulator system of Claim 14 wherein the hermetically-sealed housing comprises a tubular-shaped housing having a length no greater than about 27 mm and a cross-sectional width no greater than about 3.3 mm.

16. The neurostimulator system of Claim 15 wherein the electronic subassembly includes a ferrite core around which the antenna coil is wrapped.

17. An implantable microstimulator comprising an hermetically-sealed housing having a length no greater than about 30 mm and cross-sectional dimensions no greater than about 3.7 mm; an electronic subassembly housed within said hermetically-sealed housing; self-contained power source means within said hermetically-sealed housing and operatively connected to said electronic subassembly for providing operating power to said electronic subassembly; first and second electrodes external to said hermetically-sealed housing and electrically coupled to said electronic subassembly; an antenna coil within said hermetically-sealed housing; and telemetry means, coupled to said antenna coil, for allowing data-containing signals to be received from and sent to at least two external units through a radio frequency (RF) telemetry link, and for allowing data-containing signals to be received from at least one external unit through an electromagnetic inductive telemetry link, whereby two separate telemetry links are provided for communicating with the implantable microstimulator.

18. The implantable microstimulator of Claim 17 wherein the RF telemetry link comprises a binary frequency shift key (BFSK) telemetry link wherein a binary "1" is represented by a RF signal having a frequency F1, and wherein a binary "0" is represented by the RF signal having a frequency F2.

19. The implantable microstimulator of Claim 18 wherein the frequency F1 is within 6.3% or less of the frequency F2, whereby the frequencies F1 and F2 are close to each other, wherein both frequencies are received through said antenna coil without serious degradation whenever said antenna coil is tuned to a frequency F3, where F3 is about mid-way between the frequencies F1 and F2.

20. The implantable microstimulator of Claim 18 wherein the electromagnetic inductive telemetry link comprises an ON-OFF-KEY Pulse Width Modulation (OOK-PWM) telemetry link wherein a binary "0" is represented by a first pulse width PW1 and a binary "1" is represented by a second pulse width PW2, and wherein a transition between one data bit and an adjacent data bit is marked by a change in a transmitted data signal from an ON to an OFF state, or from an OFF to an ON state, wherein the ON state is characterized by the presence of a data signal having a frequency F1', and wherein the OFF state is characterized by the absence of the data signal.